GUSTAVUS PHYSICS

Physics Department Newsletter

September 2017

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Important Fall Dates:

Classes Begin	Sept. 5
Last Day to Register for Fall Classes	Sept. 18
Nobel Conference	Oct. 3-4
January Term Registration Begins	Oct. 30
Spring Semester Registration Begins	Nov. 6
Final Exams Begin	Dec. 15

The Mayo Clinic Connection

Over the past several years, increasing numbers of Gustavus physics students and alumni have gone to the Mayo Clinic Graduate School of Biomedical Sciences, either as graduate students or as interns in the Summer Undergraduate Research Fellows (SURF) program there.

The mission of that School is to train future leaders in biomedical research and education and to promote an academic environment at Mayo Clinic that supports trainee and faculty development and facilitates biomedical innovation.

The Graduate School was formally established as a degree-granting entity in 1989. The first Gustie physics graduate ever to attend the Mayo graduate school was **Kevin Glaser '98**, who received his Ph.D. in Biomedical Engineering (BME) there. More recent Ph.D. students there include **Dan Mellema '11**, **James Trevathan '14** and recent Gustie graduate **Nathan Huber '17**.

Dan recently completed his Ph.D. in BME, and his thesis topic involved new ultrasound techniques for determining the health of the liver. James is currently studying therapeutic uses of deep-brain stimulation for the treatment of conditions like Parkinson's disease. Nathan, who began his studies there this summer, hopes to work in the area of medical imaging.

James Trevathan '14, Dan Mellema '11 and Nathan Huber '17 with the Mayo brothers in Rochester

All three of these Gusties were also recipients of Summer Undergraduate Research Fellowships at Mayo, and each spent a summer there doing research while attending Gustavus. Other recent physics majors who were part of the Mayo SURF program are **Ian McKeag '17** and **Kevin Treb '18**. That summer program is highly competitive for admission, and is intended as a track toward possible graduate studies.

If exploring BME interests you, talk with your advisor, and be aware of the February 1 deadline for applying to the SURF program.

Faculty News

Welcome to Dr. Brianna Dillon Thomas

Brianna Dillon Thomas joins us from the physics department at St. Olaf College, where she was a visiting assistant professor. She grew up in Massachusetts but has Midwestern roots, with both parents from Indiana, where they moved back during her college years. She graduated Summa Cum Laude from Grove City College with a B.S. in Applied Physics and a minor in mathematics and holds a Ph.D. in condensed matter physics from Purdue University. As an undergraduate, she participated in summer research programs at University of California, Davis, and Lehigh University, and had a semester of research and multiple tutoring jobs within the Grove City College physics department. These experiences combined with the close knit community and mentorship of her small liberal arts college prompted her to pursue a PhD and career as a professor. Her PhD and ongoing research are on 2D quantum percolation theory, a statistical mechanical model for electron conduction in disordered systems. While at Purdue, she developed an avid interest in what physics education research tells us about how students learn and instructional techniques that help them do so more effectively, and was awarded the Department of Physics and Astronomy's inaugural Charlotte Ida Litman Tubis Award for the clear and concise written communication of physics to a lay audience. Outside of work, she enjoys spending time with her husband, cooking, reading, cycling, knitting, and music.

Dr. Brianna Dillon Thomas

She is looking forward to another year in Minnesota, although readily admits she's still apprehensive about facing a real Minnesota winter after getting it easy last year.

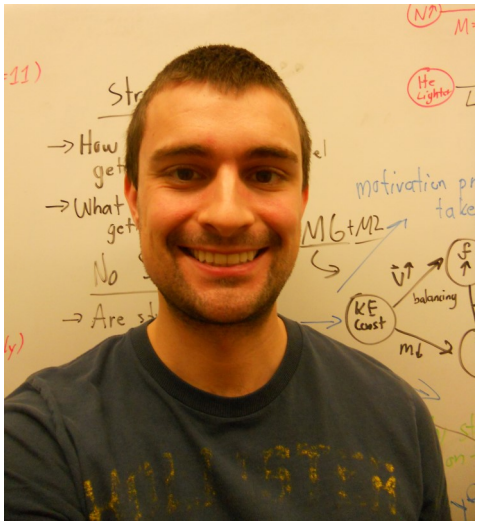
Farewell Message from Dr. Dan Young

Dr. Dan Young, Visiting Assistant Professor of Physics at Gustavus for the past three years, has accepted a permanent position at the University of North Carolina. He writes:

"I have joined a group of three other individuals who are pursuing activities in the PAER domain (Physics and Astronomy Education Research). Their current project is working to change the introductory level classes for both majors and non-majors over to a hybrid lecture-studio format. I have already had the chance to work on rewriting the studio activities, suggesting demonstrations for lecture, and coming up with biologically relevant examples that relate directly to important physics concepts.

"One thing I have noticed is that my time at Gustavus has made this transition into a significantly larger student population very manageable. I have been able to take many of the lessons I learned when I taught General Physics and apply them directly over to how I want to arrange the format of the curriculum at UNC.

"This has been a hectic but enjoyable transition for me and I want to thank everyone in the Gustavus physics department for both my time in Minnesota and for making this possible. I felt like a member of the Gustavus physics family and garnered many phenomenal memories and friends that have made a large impact on my expression onto the academic domain. I was very sad to have to leave but I am hoping that I will be able to experience the same amount of growth at UNC that I achieved at Gustavus, and I cannot thank you all enough for sharing your knowledge and helping me get to where I am today.



Dr. Daniel E. Young

"And yes, believe it or not, I really will miss the winter weather in Minnesota!"

Faculty Summer Plans Include the Total Solar Eclipse

Brianna, Darsa and the students viewing the eclipse

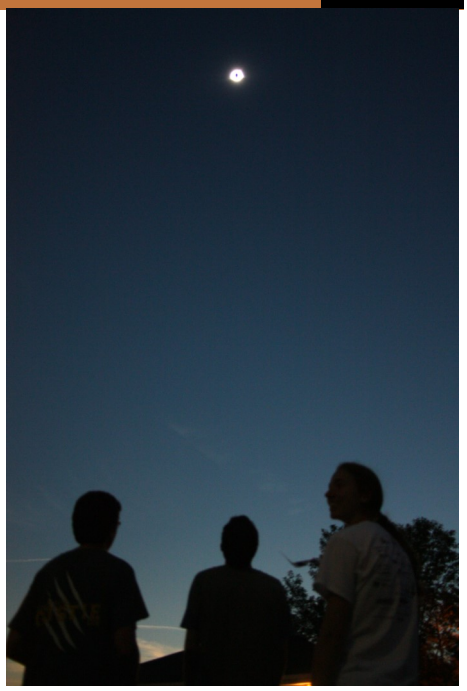
On August 21, **Darsa Donelan** and **Brianna Dillon Thomas** made a road trip south to the eclipse totality, along with **Travis Boskowitz '18**, **Tasnim Lamisa '19** and **Vatsala Adile '20**. This summer Darsa attended several teaching workshops, hearing talks by leading innovators in physics and astronomy education, and working in small groups to develop applications of teaching techniques. Darsa will use the ideas and techniques presented at these workshops to directly impact the teaching of the General Physics, Cosmic Universe, Mechanical Universe, and Electromagnetic Universe labs as well as the Astronomy course. She also began a research project with **Sam Maruska '20** and **Elijah Fourre '20** to create a cooling system powered by Fresnel lenses. As this newsletter goes to press, Darsa is participating in Dragon Con's Miss Star Trek Universe as The Borg.

Steve Mellema, spent most of the summer in Asia on his sabbatical leave, visiting Singapore, Hong Kong and Japan in addition to Malaysia. So, after seven months away, he did not leave St. Peter on August 21. He hosted an on-campus eclipse event, which fell victim to rain. Steve will teach The Cosmic Universe and Quantum Mechanics this fall.

Paul Saulnier also stayed in St. Peter on the eclipse day. In the upcoming academic year, Paul is scheduled to teach Thermal & Statistical Physics and Experimental Modern Physics (with Chuck Niederriter) in the fall and tentatively Quantum Universe and Optics with lab in the spring. Additionally, Paul will serve as the pre-engineering advisor and seminar coordinator for the department.

Tom Huber had NSF funding to allow him to collaborate with **Matthew Mehrkens '18** and **Ben Rorem '19** on ultrasound and acoustics research. This was the first year of a three-year grant funded by the National Science Foundation. The goal of this project was to use a laser interferometer to visually measure ultrasound waves in water and air. He continued his collaboration with the physics department at Rhodes College (Memphis, TN) imaging of ultrasound propagation through bone. On his way to Memphis to meet with his Rhodes collaborators, Tom and his family stopped in Oak Ridge, Missouri to view the eclipse. Tom will be on sabbatical in spring 2018.

Jessie Petricka writes, "I spent the majority of the summer researching with **Ezekiel (Zeke) Haugen ('20)** and **Travis Boskowitz ('18)** who were supported by the First Year Research Experience and Presidential grants, respectively. We worked on the ion trapping project where the main improvement was to confidently calibrate the time-of-flight detection signal. The remainder of the summer was spent camping, and 'recovering'." In the fall, Jessie will again teach Electromagnetic Universe and Lab, and FTS: Compared to What, along with advising the Society of Physics Students.



Silhouette of the Huber Family and the Total Eclipse

The Petricka family went to view the eclipse, but didn't stray too far from home. Jessie says, "It wasn't quite totality but the dark eclipse ice cream was at least 85% good."

Chuck Niederriter was busy this summer working with **Saad Tariq '19**, **Tung Lee Xuan '19**, **Tasnim Lamisa '19** and **Vatsala Adile '20** on a variety of projects. He also did the usual robotics and high altitude ballooning camps, presented at the summer AAPT meeting, and traveled to Pennsylvania and to Oregon to watch the solar eclipse. The prize for best eclipse photo goes to Chuck**,** and it is shown below.

Chuck's "Diamond Ring" Photo

Gustie Encounters

Emilie Benson '16 and Roman Mays '14 at Penn

Tom Huber, Dorea Ruggles '06, Bruce Olson '78, and Will Doebler '15 at the ASA meeting

You never know where you're going to run into a fellow Gustie physics alum. **Emilie Benson '16** who is pursing her Ph.D. in physics at the University of Pennsylvania, sent this photo taken in a laboratory clean room there. Beside her is **Roman Mays '14**, who was an engineering graduate student at Penn.

Emilie writes, "I am currently working in a condensed matter lab on ovarian cancer detection using DNA functionalized carbon nanotubes. I am frequently in the clean room for device fabrication as we use photolithography."

Roman writes, "Recently, I have graduated with my Masters in Mechanical Engineering and Applied Mechanics. Because of this past year of doing research in the cleanroom, I found that I want to understand the underlying physics and chemistry of the processes, and am hoping to use the career experience to springboard into a PhD program for Materials Science. I am hoping that I will be able to adapt my knowledge of physics, mathematics, mechanical engineering, and materials science to be on the forefront of energy research."

At the annual meeting of the Acoustical Society of America (ASA), Gustavus was well represented. The second photo above shows **Professor Tom Huber** along with **Dr. Dorea Ruggles '06**, **Bruce Olson '78**, and **Will Doebler '15**. Dorea, winner of the 2016 Gustavus Alumni Association's First Decade Award, is Research Associate at the University of Minnesota studying the human auditory system. She received her Ph.D. in Biomedical Engineering from Boston University. Bruce (although not a physics major) founded the Olson Sound Design company, and from his offices in the Twin Cities has worked over the years with several Gustavus undergraduate physics students on acoustics-related projects. (Dorea was the first Gustavus student ever to work with Bruce.) Will is pursuing his Ph.D. in acoustics at Penn State University. While he was a student at Gustavus, he worked as a research assistant in Dr. Huber's ultrasonic acoustics lab.

Speaking of Will, the photograph below shows him during a break at the ASA meeting along with Dr. Thomas Rossing, a legend in the world of acoustics. Aside from writing the classic undergraduate textbook on the subject, Dr. Rossing was a leading researcher in acoustics for decades. In his retirement, he founded the Rossing Fund for Physics Education Endowment through the Evangelical Lutheran Church in America Foundation. Will is one of the 11 Gustie physics majors in the past seven years to receive a scholarship from the Rossing Endowment.

Will Doebler '15 at the ASA meeting with Dr. Thomas Rossing

Three Gustie Physics Majors Win Rossing Scholarships

For the second year in a row, a total of three Gustavus physics majors have won scholarships from the Thomas D. Rossing Fund for Physics Education.

Elise LeBoulicaut '18. was one of only three students nationwide to receive a $10,000 Rossing Scholarship award for 2017-2018 . A rising senior from Angers, France, Elise had a research internship during the summer of 2016 at the College of William and Mary, where she worked to develop algorithms to predict risk of infection in premature infants. In 2016-2017 Elise was the winner of Gustavus' John Borneman Prize Par Excellence in Mathematics, presented to an outstanding student in the fields of mathematics and physics. This summer, she is working in Geneva, Switzerland for the world-renowned Conseil Européen pour la Recherche Nucléaire (CERN) under the auspices of a research internship from Duke University. She says that the work there has stimulated her interest in pursuing graduate studies in high-energy physics.

Ben Rorem '19, was one of nine students across the nation to receive a $5,000 Honorable Mention scholarship from the Rossing Fund for 2017-2018. Ben had an internship during the summer of 2016 with **Dr. Chuck Niederriter**, funded by the Gustavus First-Year Research Experience (FYRE) program. They worked on building a wind-power amplification system using a venturi design to increase the wind speed. This summer, Ben is working with **Dr. Tom Huber** in ultrasound acoustics, under the auspices of a National Science Foundation Research at Undergraduate Institutions (RUI) grant. They are using a scanning laser vibrometer to measure the speed of sound in samples of human bone, for use as a diagnostic of bone density in the study of osteoporosis.

Xiaoqi Yu '19, from Wuhan, China, also received a 2017-2018 Honorable Mention scholarship of $5,000. During the summer of 2015, she had a FYRE internship working on optical scattering at Gustavus with **Dr. Steve Mellema**. For the past two summers, she has been working at the Chinese National Astronomical Observatories in Beijing. Her work there involves computational cosmology.

Funded by Dr. Thomas Rossing, the fund awards annual scholarships to students enrolled at one of the 26 colleges and universities affiliated with the ELCA who are pursuing an education in physics. Applicants are nominated by their institution's professors and selected by the foundation based on the student's academic and research standing. For the second year in a row, Gustavus was the only ELCA institution to win three awards in a single year.

Baccalaureate Origins of Eventual Physics Ph.D.'s

The National Science Foundation maintains the WebCaspar database tracing the baccalaureate school of every student who completes a physics Ph.D. at a US institution. The data are now available through calendar year 2015. They show the following to be the top liberal-arts-college sources of physics Ph.D.'s for the ten years from 2006-2015 (number of Ph.D.'s in parenthesis):

Harvey Mudd College (68)
Swarthmore College (42)
Reed College (39)
Williams College (35)
Carleton College (33)
Gustavus Adolphus College (23)
Lawrence University (23)
Grinnell College (19)
Amherst College (18)

Departmental Awards for 2017-2018

At the annual spring picnic, the Physics Department announced its awards for the upcoming year. The recipients of these awards are decided each year by the physics faculty.

Clark Hickman '18 is the recipient of the Milward T. Rodine Memorial Physics Award, named for the founder of the Gustavus Physics department who taught here between 1933-1969. It is awarded on the basis of interests and scholarly achievements to a physics major who has completed the junior year.

Xiaoqi Yu '19 is the winner of the John Borneman Prize Par Excellence in Mathematics, which is decided by the faculty of the Department of Mathematics, Computer Science and Statistics in consultation with the physics faculty. This award was designated in memory of John Borneman '55 by his family, and is presented to an outstanding student in the fields of mathematics and physics.

Elise LeBoulicaut '18 has received the John Chindvall Scholarship in Physics, endowed in memory of John Chindvall '70 by his parents and friends, and presented to a student majoring in physics.

Matthew Mehrkens '18 was awarded the Gerald and Julia Swanson Scholarship in Physics, established to honor the work of the physics-department faculty who provided Gerald Swanson with a background that prepared him for graduate study in physics and for a career with Bendix Corporation. The scholarship is intended to encourage physics students of promise who are enrolled full-time at the College.

Hailey Nelson '18 is the winner of the Julian A. Crawford Memorial Prize in Physics, which is named in memory of the former chair (1967-69) of the Gustavus Physics Department, and awarded to the student "with the greatest potential for contributing to physics and society."

Kristen Cash '20 and **Ezekiel Haugen '20** were the recipients of the Harold Q. Fuller Memorial Award in Physics, given to the first-year students who achieve the highest overall record in physics courses. This award was established by Professor Emeritus **Richard M. Fuller** (who taught here from 1968-1999) and his wife Judith. It honors Richard's late father ,"HQ" (a researcher in the Manhattan Project, physics professor and dean at the University of Missouri, Rolla), for his lifetime commitment to the teaching of young people.

Ryan Sullivan '18 received a "Positive Derivative Award", as a physics major who showed great improvement during the 2016-2017 academic year.

Kelly Neubauer '18 and **Ryan Sullivan '18** will serve as the Physics Departmental Assistants for Fall Semester 2017. These positions have a nominal expectation of four hours per week in research, course development or other activities that will assist in the work of the department.

Sigma Pi Sigma Induction Banquet

On Saturday, May 6, the Physics Department held the annual induction banquet for Sigma Pi Sigma, the national physics honor society. This was the 13th class of seniors inducted into ΣΠΣ since the founding of the Gustavus Chapter in 2004.

After opening remarks from Gustavus President Rebecca Bergman, the keynote lecture was delivered by **Dr. Carl Ferkinhoff '05**. Immediately after graduating from Gustavus, Carl served for two years in Teach for America, teaching high-school

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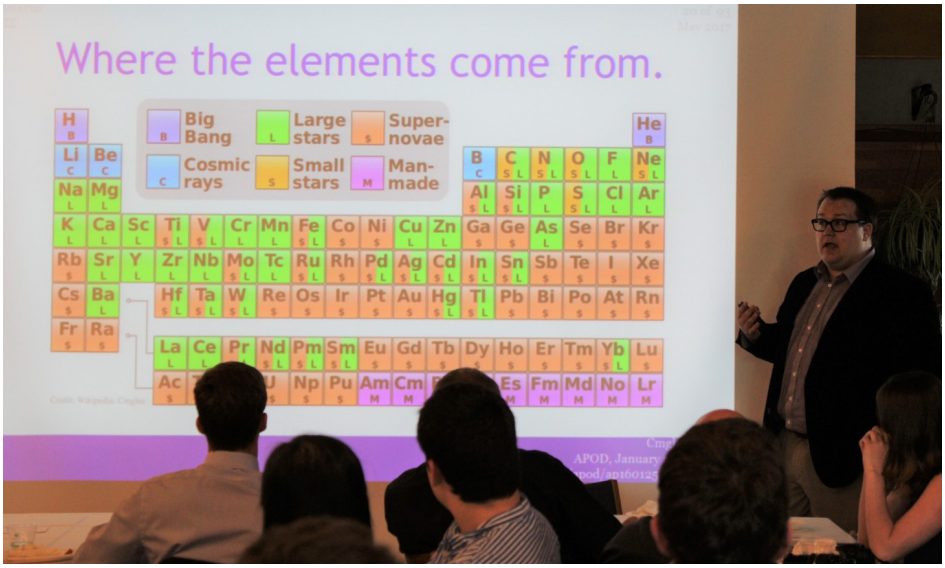

Dr. Carl Ferkinhoff '05 delivers the 2017 Sigma Pi Sigma Lecture

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chemistry and physics in inner-city Baltimore. He then attended graduate school in Astronomy at Cornell University, where he received his Ph.D. After two years as a Postdoctoral Research Associate at the Max Planck Institute for Astronomy in Heidelberg, Germany, Carl accepted a position at Winona State University, where he is currently Assistant Professor of Physics. Carl's talk was entitled "Extreme Science! - Submillimeter Instrumentation and the Study of Galaxies in the Early Universe."

2017 Sigma Pi Sigma Inductees
Back Row (L to R): Nathan Huber, Mikaela Algren, Will Riihiluoma, Ian McKeag, Nicholas Hulstrand
Front Row (L to R) Grace Kerber, Derek Huntley, Rochelle Widmer, James Bork

Sigma Pi Sigma is a member society of the American Institute of Physics, with about 4,000 active members in over 500 chapters nationwide. It exists to "honor outstanding scholarship in physics; to encourage interest in physics among students at all levels; to promote an attitude of service of its members toward their fellow students, colleagues, and the public; and to provide a fellowship of persons who have excelled in physics."

Founded in 1921, Sigma Pi Sigma is a member honor society of the Association of College Honor Societies. The society has some 75,000 historical members. Election to Sigma Pi Sigma is a lifetime membership.

At Gustavus, election into Sigma Pi Sigma requires involvement in the department's' chapter of the Society of Physics Students (SPS) as well as nomination by at least two of the department's faculty members. Minimum criteria for election include a grade point average of at least 3.0 for all physics courses taken, plus satisfaction of one of three induction tracks: research, academic, or service.

The members of the class of 2017 inducted were: **Mikaela Algren, James Bork, Nathan Huber, Nicholas Hulstrand, Derek Huntley, Grace Kerber, Ian McKeag, Will Riihiluoma and Rochelle Widmer**.

Congratulations to these nine outstanding physics graduates. To learn more about them and their future plans (in their own words) see the article that begins on page 10.

Professor Milward T. Rodine Added to the Physics Emeritus Wall

At the annual Sigma Pi Sigma banquet, a photographic portrait of Professor **Milward T. Rodine** (taught 1933-1969) was unveiled, and now hangs on the "Emeritus Wall" in the 2nd-floor physics lobby of Olin Hall.

Professor Rodine founded the physics department after he came to the College in 1933, but was never elected to emeritus status on the Faculty because he passed away in 1969 while still actively teaching.

His son, Earl, and Earl's wife, Carol, (both Gustavus alumni) were present at the unveiling of the portrait, which joins those of Emeritus Professors **Richard M. Fuller** (taught 1968-1999) and **Dennis C. Henry** (taught 1978-2009). They remind us daily of how the department was built by hard work and dedication.

Professor Milward T. Rodine

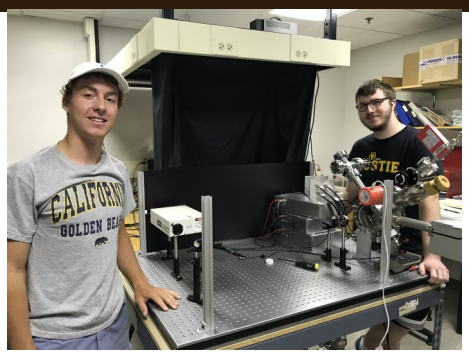
Student Summer Internships

During the summer of 2017, a number of physics majors had technical and research internships around the country. Some of them have written to share their experiences.

Matthew Blomquist '19 writes, "This summer, I am interning at Polaris Industries at the plant in Wyoming, MN. I am working with a team of 12 project engineers who work on the powertrain of current and future Polaris vehicles. I have a wide range of tasks that I am working on, some by myself and some working with the engineers on the team. For example, I have created Microsoft Excel sheets that are organized to receive and format information that make looking up information much faster for the engineers, compared to the way that they used to look up information. I am also working with a couple of engineers on the engine changes of a future Polaris vehicle. In the future, I am hoping to become some sort of engineer, and what is great about the Wyoming plant is that there are 600 employees, and 400 are engineers, so I am surrounded by tons of engineers of various fields every day!"

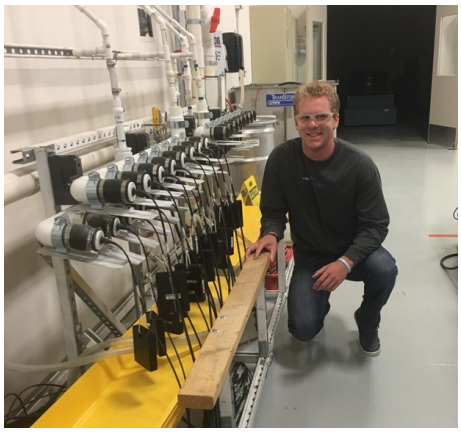
Travis Boskowitz '18 and **Zeke Haugen '20** have been working with **Dr. Jessie Petricka**. Zeke says, "I am working at Gustavus in the first-year research (FYRE) program. Travis and I are doing molecular ion trapping and collision-rate measurements using laser ablation, a quadrupole trap and ion time of flight. We will be recommissioning the time of flight apparatus and carrying out chemical reaction studies. "

Travis adds, "We are working on bringing it back to operating shape and hopefully to be able to take some chemical-reaction data by the end of the summer! Mostly we are working to calibrate the TOF with our new detector installed."



Zeke and Travis in the Ion-Trap Lab

Scott Eischens '18 writes, "I am working at CommScope in Shakopee as a Product Development Intern on the fiber optic connector team. So far this summer I have been tasked with two main projects. The first was to improve the heat shrink process for sealing connections from leaking for usage outside and underground. The second project is to bias the fiber core to the top of connectors so that when they are mated with another connector the IL (insertion loss) is minimized. The goal of both of these projects is to be able to implement them in production for use worldwide. I am the head of both of these projects and have done most of the research and implementation on my own with assistance from the other engineers on my team. "



Scott on the job at Commscope

Katy Hagen '19 says, "I am working at the University of Minnesota Twin Cities in the Life Sciences Summer Undergraduate Research Program (LSSURP), specifically the Neural Systems Engineering group. I work in the Center for Magnetic Resonance Imaging building, which requires a lot of specialized training to even gain building access. Due to the high magnetic fields, there are a number of warning signs as you enter into a higher field zone prohibiting things like cards with magnetic strips, digital watches, cell phones, and people with metal implants in their body. They have a number of magnets here, with their strongest being about 10 Tesla.

"My project concerns visual perceptual learning, the ability to improve at a visual task over time. This is extremely specific to one task, shape, orientation, etc. I am using both human, and macaque monkey subjects. Functional Magnetic Resonance Imaging (fMRI) takes images of brain activity while a subject is performing a visual task where they perceive a circle within a noise signal. They enter the magnet twice; once before they undergo training, and once after they have been trained on a similar task. This provides a way of seeing how the training causes changes in their brain activity while being recorded in the magnet a second time.

"Training involves psychophysical analysis of eye movements using an eye tracker, which accurately follows a subject's gaze to determine whether they are performing the task correctly. Ideally, within a couple weeks, I will be able to analyze and compare the fMRIs to determine what structural changes have occurred while the subjects have been learning."

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Clark Hickman '18 in an NSF REU program through the Electrical and Computer Engineering (ECE) Department at Montana State University in Bozeman.

Clark in the Rocky Mountains

He says, "I'm in a bioengineering lab that is working on growing, imaging, and manipulating neural networks. One of the projects going on in the lab currently involves micro fabricating wafers with different patterns and solutions on which the neurons can grow to observe how different factors affect neuronal growth. Another consists of growing neurons with transfected genetic material that allows tau proteins to be imaged fluorescently. Another is modeling how nanomagnetic forces applied to the neurons affect their growth and behavior. And finally, I am working on a project to fluorescently label calcium concentrations in neurons (closely related to action potentials) inside of an incubator (to better model body-like conditions). Ultimately, my design will have enough flexibility to allow for imaging tau and calcium inside the incubator concurrently while nanomagnetic forces are being applied to it, tying the projects together.

"The lab work is fun, but what I find most interesting here are all of the outdoors opportunities around Montana. I have been hiking or camping every weekend and have visited Yellowstone and will visit Glacier NP and Banff NP (in Canada) before I leave."

Elise LeBoulicaut '18 writes, "This summer, I participated in the Duke/Triangle Universities Nuclear Laboratory REU program. I spent the first 4 weeks at Duke University in Durham, NC and the next 6 weeks at CERN in Geneva, Switzerland. Throughout the summer, I worked on different aspects of high-energy particle physics and specifically the ATLAS detector at the Large Hadron Collider (LHC). During my time at Duke, I worked on a cooling system used to test new silicon modules that will be used in an upgrade of ATLAS. I wrote a LabVIEW program to control and measure the temperature inside the cooling system, which I then compared to a 3D COMSOL simulation of the apparatus, which I also created.

Elise on the CERN campus

"I am learning a lot this summer about nuclear and particle physics through various lectures, seminars and visits. I toured many facilities at Duke, the University of North Carolina, North Carolina State University and of course CERN (although I was not able to go in the underground tunnels because the accelerator was running). I have found that I very much enjoy this type of physics, both the theoretical and technical aspects. I also enjoy life in Geneva and at CERN, where the atmosphere is relaxed, yet productive. I am grateful for this experience, which is both providing me which an incredibly fun summer as well as a building block towards graduate school."

Kelly Neubauer '18 writes, "I am conducting research at the University of California–Davis as part of their REU program. I am part of a team in the experimental condensed matter physics department that synthesizes new materials such as Cr-based magnets, Fe-based superconductors, and Ce-based heavy fermions. My project includes growing $(FeCo)_2B$ crystals and studying their physical and magnetic properties.

"Single crystals of $(FeCo)_2B$ are grown using a solution-growth technique. This technique includes using an arc-melter to prepare polycrystals of the material, using a torch to seal samples inside ampoules, heating ampoules in a furnace at 1200°C, cooling to 1150°C over several days, and separating the solutions from the crystals using a centrifuge before the sample has solidified after removal from the furnace. Crystal properties are then determined using an x-ray diffractometer, physical property measurement system, and magnetic property measurement system. Magnetic properties are measured as a function of temperature (from 2 K to 320 K) and magnetic field (up to 7 Tesla).

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The Physics Graduating Class of 2017

The class of 2017 contained 16 physics majors. Some of them have provided information about their Gustavus experiences, future plans or their advice for other Gusties.

Mikaela Algren writes, "Many of my fondest memories from Gustavus were made through our physics community. I feel lucky to have tackled the challenges of the program with such a fun group and supportive family of students and professors. As I transition now to a PhD program in Hydrology at the Colorado School of Mines, I hope to share with new friends and colleagues some of the joy for life and learning my friends at Gustavus have shared with me over the past few years. To all those who have touched my heart and mind, thanks for everything, and please contact me—I'd love to hear from you! To the students still working on their degrees: it seems to me that the most difficult things turn out to be the most worth-doing, so be proud of what you've accomplished, and don't be afraid to challenge yourself. Also, I think net energy flux through your soul (or something like that) is zero, so you probably need to pour your heart and your energy into your pursuits and the people around you so that opportunities for growth and love can flow in. Best of luck to all of you."

Courtney Bethune says, "This fall I will be attending University of British Columbia for Mechanical Engineering. I hope to get involved in the renewable industry in the future with the hopes of working on cars, as that has always been a passion of mine, but I would also be interested in the solar or wind industry. One awesome thing about Gustavus is how much everyone really cares about the ongoing problem of global warming and greenhouse gas emissions. The physics professors are very involved and have great knowledge on these issues and are a great resource for becoming more involved on campus at Gustavus. There is also divestment and some other groups on campus you can get involved in.

"My words of wisdom for future students is to get involved! Try new things and join groups on campus to expand your knowledge. There are so many religion, art, history, political, and language courses that can expand your knowledge beyond science and are important for everyday life. Also if you get the opportunity, study abroad. Life experiences are the best experiences."

James Bork says, "I am attending the University of Delaware for a PhD in Materials Science. Upon arri-

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val here, I was met with a sense of familiarity. It shares the sense of community, approachable and friendly (yet offbeat and quirky) nature of professors, and relaxed atmosphere that the physics department at Gustavus has fostered—something I've come to expect of a good department, and something I can say isn't present in every graduate program or department at Gustavus. Gustavus physics is a very special department that has set the bar high for itself and for its students. Best wishes to fellow and future graduates. Thanks, physics faculty, for everything (even the homework)!"

Chris Heintzelman is in the Masters program in Electrical Engineering at the University of Minnesota.

Nathan Huber writes, "I am attending Mayo Graduate School and studying biomedical engineering. I hope to pursue a career in medical imaging research.

"I would encourage students to seek out research opportunities and practice programming. These are enjoyable ways to apply coursework and learn new things."

Nick Hulstrand's words of advice to future physics graduates are, "Find out the things that you aren't good at and, if you think they are important, work to improve on them. Really challenge the things you want to change because change isn't easy, and it doesn't have to happen. Two issues that I have seen plague many students are procrastination and anxiety. My best advice for both of these is to do something, immediately, take any action that addresses the issue and do this for 5 minutes. By the end of those minutes, one of three things will be true: the thing will be done because it wasn't as hard as you had feared; you'll be engaged in the work and can allow momentum to carry you away from the hurdle of starting; or you will back where you started with more progress and can try again. There is other advice such as working with others to strengthen commitment and give help, but none of these work unless you start, so take action!"

Derek Huntley says, "I had a great experience at Gustavus, and feel as though all of the in-class as well as the extra-curricular activities have prepared me for the future. As for my future, I am attending the University of Minnesota in the Department of Mechanical Engineering. My advice for physics students is to stick it out. Everyone is going to have that moment where it gets 'too hard' or you 'want to quit', but it's definitely worth it in the end. Use your resources around you and fight through the struggles!"

Grace Kerber writes, "During my time at Gustavus I had the opportunity to double major (music-vocal) and study abroad (Geneva, Switzerland). I enjoyed the flexibility to be able to pursue these other interests, while still being able to be heavily involved in the physics department.

"This fall, I will begin a Physics PhD program at The University of Michigan in Ann Arbor. I don't know what project I will end up working on there, but there is a very high probability that it will have something to do with lasers.

"My words of wisdom are: start a project earlier than the night before. Don't take my advice as something I did, but something I wish I had. Have fun and enjoy your time in Olin as much as possible."

Ben Lies says, "GAC taught me a lot about critical thinking and time management while also having fun. Great atmosphere in the physics department. I am enrolled in the Ph.D. program for Industrial Engineering at Iowa State University.

"Words of Wisdom: You can get away with doing homework the night before for awhile, but eventually you'll need to start two days before. Better sooner than later."

Jill Malecha says, "Going to Gustavus was probably one of the best decisions of my life. The community at GAC creates an inclusive environment where you can explore all interests. I made friends and learned many new things about myself through the physics major, Habitat for Humanity, and other clubs.

"Right now I am working at CommScope as a mechanical engineer, working on product development for data centers. I've been able to use what I learned about optics and other math/physics courses into my projects. Within a year or so I plan on going to graduate school for project management.

"Take any opportunity that you can to get experience and learn new paths that this major can bring, whether that is working for the department, research projects, guest speakers, or internships."

Ian McKeag writes, "My experience at GAC was one of massive self-discovery and development. My professors had my best interests at heart, my friends were happy to see me grow, and my involvement with

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International Connections

Spring-Semester at *Universiti Sains Malaysia*

For more than two decades, Gustavus has had a study-abroad exchange agreement with Malaysia's largest university. This past spring, **Kelly Neubauer '18** took advantage of that exchange, and writes:

"This past spring semester I studied abroad at *Universiti Sains Malaysia* (USM) in Penang, Malaysia. This program was a perfect fit for me to both continue my academic studies and to have an incredible study abroad experience.

"Malaysia's many differences challenged me daily to adapt to, learn from, and appreciate each new experience. These experiences included making new friends from all over the world, learning about the many religions, cultural backgrounds, and languages that can shape a Malaysian's identity, adapting to living in a hot and humid climate, trying vast amounts of new (and delicious) foods, and traveling throughout Malaysia and the surrounding Southeast Asian countries.

"At USM I took the same physics courses offered at Gustavus: Electromagnetic Theory (PHY-350/ZCT 304) and Advanced Mathematical Methods (PHY-370/ZCT 219). In addition, I took a computer programming class as well as courses to enrich my cultural experience including Bahasa Malaysia and a course on world religions. USM offers many co -curricular activities (Ko-K's) including traditional music and art that could easily enrich a student's experience. I attended many events on campus including Holi (festival of colors), kung fu night, and Iftar during Ramadan.

"Malaysia is a great study abroad location. Malaysia beautifully showcases how people from diverse backgrounds can live together in peace. The people were warm and inviting to visitors and shared their kindness and love for their friends, family, and country. Malaysia renewed my hope for our world and inspired me to be kinder and more patient in life. I greatly enjoyed my time in Malaysia and would encourage others to participate in the USM program."

Kelly with new friends on the USM campus

The USM exchange is one study-abroad program where junior physics majors, like Kelly, can study abroad during the spring semester and take exactly the same physics courses that they would have taken at Gustavus. The courses are taught in English, which is a second language for all Malaysian students—another reason why study aboard for American students is very comfortable there.

If you are interested in studying abroad, talk to your advisor and to the Gustavus Center for International and Cultural Education (CICE).

Gustavus Semester in Sweden

In spring 2017, **Karl Satterlund '19** was part of the Gustavus Semester in Sweden. He says:

"This past spring I had the opportunity to chase my childhood dreams and study for five months in Sweden. Since I was able to talk, I have always had a fascination with my northern European heritage. This led me to study the language in the summers between the ages of ten and seventeen. With that in mind, to say my semester abroad was incredible would be an understatement.

One of the most impactful themes of the semester was travel. I had the privilege of exploring the Swedish countryside with a group of thirteen other Gusties. Having not had the chance to travel internationally growing up, I found the experience of airport navigation and public transit to be quite enriching. I also appreciated the variety of places I got to visit. Rarely did the group stay in one place for more than three to four weeks at a time. We toured museums, universities, and geographical sites, as well as enjoying the most traditional of Swedish cuisine. We got to go skiiing, pet reindeer, and attend concerts. Several notable destinations on the trip were the thriving city of Stockholm, the university town of Uppsala, the seaside-tourist city of Gothenburg, and the Arctic

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Circle village of Jokkmokk. Not to mention a ferry tour out to the medieval fortified city of Visby on the Baltic island of Gotland. I would say my most memorable stay was on a tiny rock island an hour outside of Gothenburg. The group rented out cabins on a coastal archipelago island in the North Sea where we were studying geology. The weather was great and the landscape was out of this world! Aside from the travel and excitement, I also got a chance to observe some of the green technology studies and implications put in place by the universities, the state, and by private firms—which I strive to become a part of someday. It would seem that Sweden has found a comfortable blend between free market economics and state-proctored programs in green technology and energy production.

All of these places and experiences made the trip so memorable, but I think the most striking aspect of my study abroad was the culture. I could clearly observe where so many of the Midwestern immigrant traits originated from during the time of the great migration. Down to the discrete mannerisms, one could see the similarities in cultural roots. But perhaps even more striking were the differences. This culture seemed to envelop so many cultures and nationalities in one. I could see it walking down the street in the restaurants, the fashion, and the music. Acceptance is a cherished value to the Swedish people, and I found this to be one of the most admirable attributes of my travels."

Karl at the "Ice Hotel" in Sweden

Fulbright Professorship Introduces Active Learning in Physics

Under the auspices of a grant from the Bureau of Educational and Cultural Affairs of the United States Department of State, **Steve Mellema** received a seven-month appointment from January-July 2017 as a Fulbright Scholar at *Universiti Sains Malaysia* (the Science University of Malaysia). USM is Malaysia's largest university, and its main campus is located on the island of Penang.

Steve had been invited by the USM School of Physics to introduce some active-learning techniques in physics education into one of their first-year courses. Working in a team with two Malaysian faculty members, they broke the large (120-student) class in Electricity and Magnetism into three sections. Two sections attended lectures that utilized Peer Instruction (using Conceptests) while the third (control) group was taught by using traditional, one-way lectures.

Students in Steve's USM first-year Electricity and Magnetism lecture section

All students took an E&M Conceptual Inventory test on the first day of the semester, and repeated that test on the last day. The groups taught using Peer Instruction showed gains in their conceptual understanding that exceeded the control group by about one standard deviation.

The class scores on actual physics tests involving problem solving showed the active-learning students scoring 10% higher than the control group by the end of the course. In addition, the final exam scores for the entire class were 10% higher than the previous year.

The USM faculty is excited and eager to integrate active learning into more of their courses. And, Steve is happy to have perhaps left a legacy in his former Peace Corps country.

Students Busy with Summer Internships

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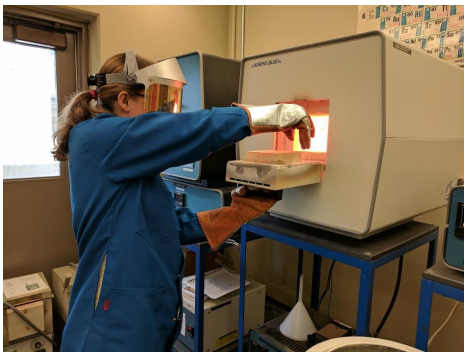


Kelly heating samples in the furnace

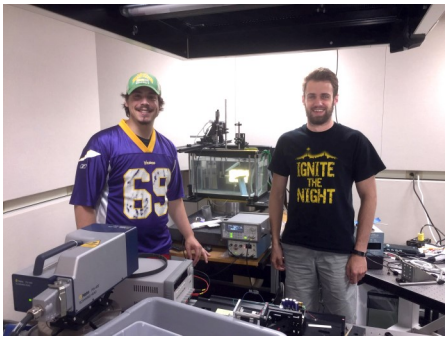
"The synthesized material is ferromagnetic and exhibits a magnetocaloric effect, which is observed as a change of temperature upon application of a magnetic field. The temperature at which this effect is exhibited can be tuned to room temperature by changing the percentage of Co in our sample. A material with these properties can be used for applications such as magnetic fridges and air-conditioning that would have less of an ecological impact than present technologies."

Ryan O'Neill '18 says, "I have been interning at Donaldson Company Inc. in their Advanced Manufacturing Technology (AMT) department. The ultimate goal of my internship is to further understand the mix equipment and the two-part urethane used as gaskets for their air filter lines.

"In many of the production lines, the mix heads are running at 9000 rpm to get a 'good' mix on the urethane. However, the mix motors have been burning out because of the high stress placed on them. I have been taking plenty of data on nine different mix head setups to figure out where the rpm limits for the mix heads are at various flow rates, and characterizing the foam. With these data, I have been working with the head administrator of the supercomputer that Donaldson owns, where he has a CFD (basically supercomputer version of COMSOL) model of CAD for the mix head setups. We're working to find what's needed to create good foam.

"The measurement of the quality and reactivity of the foam can often become, well, qualitative rather than quantitative and quite subjective. We have been looking at a new dielectric analysis method to understand the foam. By placing a small sheet with metal bars 100 micrometers apart across a roughly 1 square inch surface, and attaching every other metal bar to leads, we essentially produce many small capacitors lined up. By pouring the urethane onto this sensor, the urethane becomes a dielectric for these capacitors and, by sending an AC current through the leads, we can read the gain and phase change across the material over a fixed distance and acquire the resistivity of the material. In a fluid, most often the resistivity of a fluid is proportional to viscosity, so we are mapping out the behavior of the viscosity of the urethane. This method is proving useful and accurate, and it could revamp how they understand the urethane and save considerable time and effort when diagnosing errors in the urethane from production plants around the world."

Ben Rorem '19 writes, "**Matt Mehrkens '18** and I researched ultrasound waves with **Dr. Tom Huber** on campus. Using a Doppler vibrometer, we analyzed the reflection and transmission of ultrasound waves through human heel bone



Matt and Ben in the Ultrasound Lab

samples. The information obtained was then used to determine the validity of this process in observing signs of osteoporosis. Other projects included optimizing vibrometry methods, programming GUI interfaces, and mending a 3D printer."

Karl Satterlund '19 says, "I had the privilege of returning for a second year as an engineering intern at Pequot Tool and Manufacturing, which manufactures parts on CNC machines for other companies. Over half of our market is either firearms or aerospace components, while the other is contracted sheet metal or machined parts. The greatest part of interning at a company like this was getting to be a part of a production environment at every level.

"My role in the company was to aid in the day-to-day operations of the engineering department. This involved circulation and distribution of jobs to the shop floor, updating files on the company network, reviewing and updating prints for production, and drafting flat prints from prototype drawings for the fabrication and sheet metal department. I was also able to spend a great amount of time on the shop floor utilizing both basic and complex manufacturing tech-

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niques to produce beautiful parts. Because of the high-paced, hands-on environment in which I worked, I was able to recognize the importance of communication, asking questions, and organization, in that order.

"This summer I was able to achieve my associate level of certification in Solidworks CAD modeling software. Along with this, PTM also has a full-time training instructor who taught a class on advanced methods of geometric dimensioning and tolerancing (GD&T). This is a print-reading language that stresses relationships between a part's features rather than treating all dimensions as having equal tolerances. GD&T emphasizes the function of the part so that extra time is not spent manufacturing a feature that is less important than others. I was able to pass this and expose myself to more engineering before full immersion into the field."

Xiaoqi Yu '19 writes, "I continued my research at National Astronomical Observatories in Beijing this summer. I've been working on the field of computational cosmology studying decomposed velocity field in model f(R) gravity theory. This summer feels more like real research: I spent the first two weeks finding a bug in my Python program in order to recover the density-correlated velocity statistics, and another two weeks improving my program to higher efficiency after it shut down the supercomputer at the Institute. Then, I re-ran my codes with higher-resolution simulations in order to get better signal at small scale (the scale that current observation can reach). I finally started writing my paper last week, and hope to get it published in Physical Review D next year.

"I also went to a seminar on star-formation simulation at UC San Diego for two weeks in July (didn't expect that San Diego is way cooler than Beijing). The ideas of star formation simulation look surprisingly similar to cosmological simulation. I want to explore different fields of cosmology and astrophysics; I can probably try star formation for the next summer."

Physics Graduates Offer Their Thoughts

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co-curriculars helped strengthen my personal interests. "Currently, I am applying for jobs all around the Twin Cities area in various fields from research at the U of M to engineering firms to software companies. In the future, I'll hopefully get back to school to pursue an advanced degree.

"My words of wisdom? Embrace the whole experience. Physics has some real lows from time to time, but it also has some great highs. The faculty and peers are all available, and the upperclassmen are great resources for developing strategies to overcome some of the less fun aspects of the degree. In the end, it's totally worth it (plus there are some great stories to be had)."

Will Riihiluoma writes, "My academic experiences while at GAC are almost unilaterally positive, with the camaraderie among physics majors (both with those within my year and with others) being truly amazing. I also loved being able to pursue my other interests (Latin! Greek history!) while still having phun in physics.

"I am beginning my Ph.D. program at the University of Maine in the Physics Education Research group, and after that plan on a tenure-track teaching position at a small liberal arts college much like Gustavus.

"Wisdom, from a Physics major? Ha! But truthfully, enjoy the struggles, the defeats, and the victories with physics. You'll look back on all three with love once it's over."

Rochelle Widmer says, "I had a pretty great experience at GAC. It was nothing like what I would have expected. I made some pretty great memories and friends that I hope to keep forever.

"In the fall, I will be attending graduate school at the University of Minnesota Twin Cities. I was fortunate enough to be accepted into a Ph.D. program in the Civil Engineering department. I will be working with particle flow and river restoration. After school I plan on working as a civil or environmental engineer.

"My words of wisdom for current/future physics students is to not let schoolwork become your life. There are hundreds of new things to explore while at GAC. Try not to spend all of your time locked in the student offices or in the physics library studying into the wee hours of the night. Also, try to make friends with your physics classmates. They just might become your best friends.

My other advice is to just relax. It's just physics, right? It can't be that hard."

Gustavus Society of Physics Students

The Gustavus Chapter of the Society of Physics Students (SPS) is a perennial winner of that national organization's Outstanding Chapter Award.

SPS helps students connect with one another and with faculty. The chapter plans and hosts activities approximately twice per week during the school year in four broad areas with examples given below.

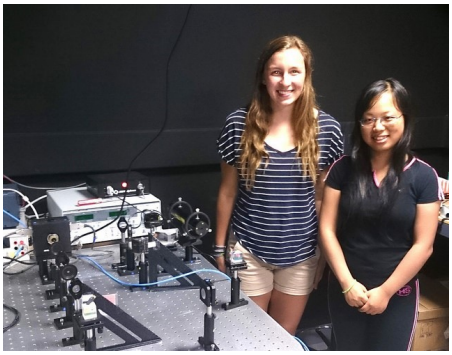
Professional Activities:

Research talks

External speakers

Alumni visits

Student research



Kelly Neubauer '18 and Xiaoqi Yu '19 in an Optical Scattering Lab

Social activities:

Frisbee, soccer, wallyball, etc.

Movies, board games, etc.

Field trips, picnics, etc.

Travis Boskowitz '18, Dr. Darsa Donelan, Rochelle Widmer '17 and Eli Sontag '18 on an SPS camping trip this spring

Service to the community:

Elementary school physics shows

Adopt-a-highway, Habitat for Humanity, etc.

College / environmental sustainability

Vatsala Adile '20 working with elementary school students at the "Science on Saturday" event

Career development:

Journal club

Internship and graduate school workshops

Alumni networking

Hailey Nelson '18 and Elise LeBoulicaut '18 demonstrate optical spectroscopy at an event for adults at the Science Museum of Minnesota

The faculty advisor for SPS is **Dr. Jessie Petricka**. The SPS officers for 2017-2018 are:

Co-Presidents:
Elise LeBoulicaut '18,
Matt Mehrkens '18

Treasurer: **Patrick Neri '18**

Communications: **Ben Rorem '19**

Activity Coordinator:
Ryan Sullivan '18

Junior Representatives:
Hannah Nolte '18,
Karl Satterlund '19,
Xiaoqi Yu '19

Sophomore Representative:
Vatsala Adile '20

The 2017-2018 year for SPS will kick off with the annual opening meeting during the second week of classes. At that meeting, physics faculty members will introduce themselves and their research programs, hoping to recruit some new students who want to collaborate in those efforts. There will also be liquid-nitrogen ice cream. The meeting time will be announced in the first week of classes.

This Newsletter is issued at the beginning of the fall semester for the benefit of students, alumni, faculty and others interested in the physics program.

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